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THE

FLEET OF THE FUTURE:

IRON OR WOOD?

CONTAINING

A REPLY TO SOME CONCLUSIONS OF GENERAL SIR HOWARD
DOUGLAS, BART., G.C.B., F.R.S., &c., IN FAVOUR OF
WOODEN WALLS.

BY

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INSTITUTION OF NAVAL ARCHITECTS.

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THE

FLEET OF THE FUTURE:

IRON OR WOOD?

THE question between wooden walls and iron defences has become so important to the security and independence of England, that it can no longer be treated as a theoretical and technical speculation merely. It is one upon which practical issues of national importance must at once be taken.

It is unfortunate, that at so critical a moment, a distinguished general officer of great knowledge and high rank, Sir Howard Douglas, should have come forward as the advocate of wooden walls. But that circumstance makes it the imperative duty of those who believe in the greater efficiency of iron defences to meet his arguments and refute his conclusions.

It is well known that for some twelve or fifteen years, distinguished men, in the navy and out of it, have been gradually coming, by a course of practical experience and careful observation, to the belief that iron ships possess many advantages over wooden ships for purposes of war. Some fifteen years ago it was found by Captains Hall and Charlewood that in action iron vessels presented the advantages of turning aside shot fired obliquely; of being more easily repaired when damaged; and of being less easily set on fire than wooden ships. Some twelve years ago I built some iron vessels of war which possessed the advantage of carrying heavier armament, drawing less water, and steaming faster than any wooden vessels of war of the same size, and they afterwards did good service in the Sea of Azof.

But the capture of Kinburn seems to have been the turning point in this question, as the effects of shot on the iron-plated vessels of the Emperor Napoleon satisfied him of the comparative invulnerability of iron sides, and decided his policy for the future in favour of iron defences.

Encouraged by his example, the advocates of iron war ships in England have continued to urge their views with increased energy and tardy success. At this moment it is believed that France has gained material advantages by her willing and ready adoption of iron-coated ships, and that we have lost much by our tardy and reluctant adoption of the new element of defence.

As naturally happens, a large and strong party has opposed an iron war fleet as a novelty, and have done all in their power both in the Admiralty and out of it to retard the introduction of iron. Sir Howard Douglas is the exponent of the views of this anti-iron party. He proves in his pamphlet on iron defences, to which I propose some reply, that he has been for many years the influential and successful opponent of the use of iron for ships of war. How he has exercised that influence he frankly tells us. "*I was consulted by the late Sir Robert Peel, on his accession to the government, as to the use and efficiency of a certain half-dozen iron frigates, two of which were finished, and four constructing by contract. I stated in reply that vessels wholly constructed of iron were utterly unfit for all the purposes of war, whether armed or as transports for the conveyance of troops.*" How fatally successful this advice was we now know only too well.

In his most recent publication on this subject Sir Howard Douglas continues to use the same arguments to the same effect. It is therefore necessary to state and refute them. We state the case against iron ships in his own words.

"The question which I proposed to examine was as follows:—Whether ships constructed wholly, or nearly so, of iron, are fit for any of the purposes and contingencies of war. I came to the following conclusion:—first, That ships formed wholly, or nearly so, of iron, are utterly unfit for all the purposes and contingencies of war, whether as fighting ships or as transports for troops; 68-pounder solid shot would pass through the "Great Eastern" with tremendous effect, and the perforation in the outer shell could not be plugged up; she is an awful roller, and has never attained anything like calculated speed; second, That thin plates of iron, even ⅝ of an inch thick, are proof against shells or hollow shot in an unbroken state, but that the fragments of the shot and shell pass through the plates and produce an effect perhaps more formidable than any shell; third, That being proof against shells will avail little unless the vessels are likewise proof against solid shot; fourth, That the thickness of plates required to resist shot fired from the heaviest nature of gun must not be less than 4½ inches." To this he adds that if the iron be not backed by wood, the thickness must be increased to 6 or 8 inches.

Such are Sir Howard Douglas's conclusions. The arguments by which he supports them are not so easily condensed. He founds them partly on a long series of experiments made by the Admiralty, and communicated to him for publication. These experiments show that a plate of iron, struck repeatedly in one place, will at last be broken. This seems to us to be his ruling fact. He then argues, that as the thickness of such a plate must be six or eight inches, or more, no ship can be built to carry such a weight, and, at the same time, retain the qualities of a good ship. He thus constructs a dilemma, out of which he thinks the advocates of iron cannot escape; as thus—More than six or eight inches of thickness are necessary to the perfect impregnability of iron. This weight of iron cannot be carried without destroying the sea-going qualities of a ship. Therefore, a vessel of war cannot be made at once impregnable and a good sea-boat.—Q. E. D.

In reply, I shall have to state that the respective merits of wood and iron are not tried truly on this issue. There is no such question raised by those who prefer iron ships of war to wooden ones, as this of Sir Howard Douglas. Absolute theoretical impregnability is an absurdity. It is difficult to conceive a plate of iron so thick, that if you go on continually firing 68-pound shot on the same place you will not at length injure the plate.

The question at issue is this.—Is iron less liable to injury by the missiles of modern warfare than wood? not, Is it absolutely invulnerable? Can iron of moderate thickness be so arranged in the formation of a ship as to give it a much higher degree of invulnerability than wood? And can a ship, so protected, have as many or more good qualities than a wooden ship of the line? And will the balance of advantage lie, on the whole, with the wood or with the iron?

I undertake to show that there are means known to us by which vessels of iron may be constructed so as to have, on the whole, a large balance of advantage over wood. And I also undertake to state the general conditions under which these results may be obtained, and an iron fleet constructed in every way superior to a wooden fleet.

Preliminary, however, to the main argument, I am obliged to show that one of the facts on which Sir Howard Douglas concludes against iron ships, even the most large and powerful, is an assumption of his own, and not a fact; he states:—

> THAT SHIPS FORMED WHOLLY, OR NEARLY SO, OF IRON, ARE UTTERLY UNFIT FOR ALL THE PURPOSES AND CONTINGENCIES OF WAR, WHETHER AS FIGHTING SHIPS OR AS TRANSPORTS FOR TROOPS; 68-POUNDER SOLID SHOT WOULD PASS THROUGH THE "GREAT EASTERN" WITH TREMENDOUS EFFECT, AND THE PERFORATION IN THE OUTER SHELL COULD NOT BE PLUGGED; SHE IS AN AWFUL ROLLER, AND HAS NEVER ATTAINED ANYTHING LIKE CALCULATED SPEED.

As designer of the lines of the "Great Eastern," and as professionally responsible for all her sea-going qualities and points of naval architecture, it becomes my duty not to allow the public interests to suffer, as they must do, if these facts are assumed *and deductions* accepted and acted upon by the Legislature, which in the ensuing parliament must vote its money either for the construction of the new fleet or the continuation of the old.

Sir Howard Douglas's conclusion consists of:—

1. A fact.—The " Great Eastern " is an awful roller.

2. Another fact.—The " Great Eastern " has never attained anything like calculated speed.

3. A prediction.—68-pounder solid shot would pass through the " Great Eastern " with tremendous effect.

4. A belief.—" The perforation in the outer shell could not be plugged."

5. A conclusion.—" Ships formed wholly, or nearly so, of iron, are utterly unfit for all the purposes and contingencies of war, whether as fighting ships or as transports for troops."

I undertake to show—

1. That the alleged fact is the exact contrary of the truth.

2. That the second fact is like the first.

3. I shall give a measure for the meaning of " tremendous effect."

4. I shall define the limits of the belief that the perforation in the outer shell could not be plugged.

Lastly. I shall show that the true facts, even in the form in which Sir H. Douglas could not escape adducing them, have disproved his own conclusions.

After having negatived Sir Howard Douglas's conclusions, I think I shall be able to establish the following counter-conclusions:—

1. That iron steam-ships of war may be built as strong as wooden ships of greater weight, and will be stronger than wooden ships of equal weight.

2. That iron ships of equal strength can go on less draft of water than wooden ships.

3. That iron ships can carry much heavier weights than wooden ships.

4. That they are more durable.

5. That they are safer against the sea.

6. That they are safer against fire.

7. That they are much safer against explosive shells.

8. That they are much safer against red-hot shot.

9. That they are much safer against molten metal.

10. That they can be made impregnable even against solid shot.

After I shall have established that Sir H. Douglas's conclusions are the reverse of the truth, I shall then proceed also to establish that the future Navy of England must be an Iron Navy. That its construction must be founded on facts and principles, which Sir H. Douglas's writings ignore, and his deductions contradict; and I believe, I shall prove that if iron war-ships had been introduced at the time when Sir H. Douglas says he sedulously and systematically opposed their introduction, the money which has since been spent on a wooden fleet about to become valueless, would already have given to England a fleet greatly more powerful than the combined navies of the world. And that now we should have had the satisfaction of having realised an enormous reduction in naval expenditure, instead of having to undertake immediately the whole cost of a new fleet in addition to the whole cost of that which it is to supersede.

I shall conclude by an attempt to define, classify, and value the future fleet of England.

I.

SIR HOWARD DOUGLAS'S CONCLUSIONS.

1. His fact No. 1.—*That the Great Eastern is an Awful Roller*

My considerate reader will easily imagine the effect which this startling announcement produced on the builder of the "Great Eastern." If there be any point in professional naval architecture which I have more deeply studied than another, and which I believe to be of greater value to the usefulness, durability, sea-worthiness, comfort and economy, whether of a mercantile ship, or a war-steamer, it is the point of easy and gentle rolling; if there be any point on which I think I have achieved greater success than another, it is the easy rolling and gentle motion of my ships. In the "Great Eastern" the accomplishment of that object gave me more thought and calculation, than any other point in her construction. Up to the moment of reading Sir H. Douglas's pamphlet, I thought I had achieved success in that way to an extraordinary degree, and that the "Great Eastern's" motions had been so gentle in kind and so moderate in degree, that she was the most comfortable and easy passenger-ship in the world. I thought everybody remembered that when in her very worst trim, she steamed through the Straits of Dover in a heavy gale, not one of the 600 passengers felt the slightest inconvenience from the rolling of the vessel; at the time when the small but good sea-boats alongside were tossed in the storm. At that time too, it should not be forgotten that 40 feet of the ship were above the water, and only some 22 feet in the water. A state in which her rolling might have been expected to be truly *awful.* It was at that time when the passengers exclaimed with delight, "After all, she *can* roll;" for up to that time the predictions of the prognosticators had been that the ship could not roll at all from the action of the sea; that for this reason the sea would strike upon her like a solid rock, and that as she could not yield to the stroke of the sea, she would be broken to pieces. The fact that she would roll gently, easily, and moderately to the action of the sea, was therefore, hailed as a good omen by the many seamen on board, and pleased with the discovery, they exclaimed "After all, she *can* roll."

I take for granted, Sir H. Douglas will not ask further proof that she has the quality every good ship ought to have, of not offering too much resistance to the action of the sea, as other vessels do; when they are too stiff and too heavy; and when in consequence of not rolling with the sea, the sea rolls over them, and damages them.

To this imputation he does not say that the "Great Eastern" is liable, but he does say that she rolls too much; that is to say, if the word awful roller means something it means this, that she rolls much more than other vessels would under similar circumstances; awfully much more of course than the wooden-ship "Hero" would do, or than the wooden frigate "Ariadne."

Happily for this argument, the same post which brought me Sir H. Douglas's pamphlet, brought me a paper from America, containing the observations made by two American engineers, and one Englishman on this very point. They determined not to trust for their own judgment of the rolling of the great ship, to vague sensations, or to record it in such words, as *awfully* great or *awfully* little. They subjected the fact to exact measurement, and they express it as follows:—

"The big ship has no keel. One rough nasty day when the sea *was* high, Mr. N. Scott Russell, and Messrs. Holley and Colburn rigged a pendulum in the state-room, and with a two-foot rule and a table of sines, we ascertained that the roll was 8 degrees to windward, and 13 degrees to leeward. That's not much." Elsewhere they say, "She certainly is not a great roller," her dining-tables are as flat as our office floor, and notwithstanding this fact, none of that wooden harness called table guards, was ever strapped to her tables during our eleven days' voyage in her, from Southampton to New York. We had rough weather too, and during the worst seas our pint-bottle of Burton ale stood proudly erect upon its own bottom at dinner."

Here, then, we have an exact scientific measure for the man of science, and a popular illustration levelled to the experience of the ordinary passenger. The *awful* roll was 10½ degrees each way, taking the average; and the awful roll during the worst sea, was not sufficient to upset the pint bottle of Burton ale. Had the American writer in his professional journal, the "Engineer," published on the 8th of December, in Philadelphia, happened to know what Sir H. Douglas was going to print in his pamphlet on the 1st of January, he could not have contrived a more apt contradiction of Sir H. Douglas's fundamental fact; but it will be easily imagined that a matter so important as the rolling of the "Great Eastern," was not left by her builder to the accidental publication of an American engineer. I had not the good fortune to make the passage to America in her myself, but I was represented there by my son, whose exact experiments I give below.

OBSERVATIONS ON ROLLING OF GREAT EASTERN ON HER VOYAGE FROM SOUTHAMPTON TO NEW YORK, 1860.

HOUR.	DATE.	EXTREME INCLINATION.	WIND.	NO. OSCILL. PER MIN.
10 A.M.	18th June.	5° each way.	Light.	
6 P.M.	,, ,,		Strong.	5·4
1 P.M.	19th June.	6° each way.	Light.	5·4
10 A.M.	20th June.	5° 30′ each way.	Light.	5·54
1 A.M.	21st June.	13° 10′ to leeward, 8° 4′ to windward.	Half gale.	5·7 *
		22nd June to 25th June Calm.		
3·30 P.M.	26th June.	3° each way.	Strong.	6·2 †

The "Great Eastern," then, is not an awful roller; but in order that Sir H. Douglas and my readers may know what an awful roller is, I subjoin the record of the rolling of our wooden walls, the "Hero" and the "Ariadne," in their recent voyage across that same Atlantic.*

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* Extreme pitching, 3° 53′—7½ per minute.

† Oscillations accelerated by the burning of the coals.

"For the credit of this noble vessel, however, I grieve to say that in this her first real trial in a heavy sea she proved rather an uncomfortable ship. It is true she was running almost before the wind, and through the trough of a very heavy sea; but, making every possible allowance for these disadvantages and her weight of coal, it still by no means accounted for her tremendous lurches. She rolled with a deep, slow, heavy motion, as if almost at times about to capsize. To say that she dipped her main-deck guns under water of course means a great deal, but even this is short of what the 'Ariadne' sometimes accomplished in her unwieldy gambols. She rolled from twenty-four to twenty-six degrees to windward, and from thirty to thirty-six or even thirty-eight to leeward. In some of her lurches over to leeward it was only possible to guess at the number of degrees she went; but her inclination may be judged from the fact, that in one tremendous dip she made she actually dipped her quarter-boats into the water. This was certainly her worst, though she very often heeled over so as to bring the boats within a few inches of the sea."

2. Sir H. Douglas's fact No. 2.—*That the "Great Eastern" never attained anything like calculated speed.*

Sir H. Douglas does not mention whose calculations he means. Does he mean my calculations, or his own calculations? or does he mean the calculations of some qualified naval architect? If he means my calculations, I have only to inform him that it was from the first 14 nautical miles, or 16 statute miles an hour in her best trim, and what she has realised is 13·9 nautical miles, or 16 statute miles, on the whole of her last voyage from America, during a great part of which she was not in her best trim, and, according to Sir H. Douglas, "rolling awfully." On this point of speed I can refer him to the printed log of her voyage, which in that respect was quite correct. If by calculated speed, therefore, Sir H. Douglas meant my calculation, he now knows that that calculation has proved perfectly correct, and, therefore, his second fact is entirely wrong.

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* See Wood's Voyage of the Prince of Wales to Canada.

But if he meant his own calculation of her speed disappointed him, then I infer that he must have calculated on wrong data, and I will now proceed to give him the correct ones. Sir H. Douglas knows that the speed of a vessel depends mainly on the propelling power applied. If small power is applied to the ship she goes slower, and if large power is applied to her she goes quicker. The proportions of power in practical use are as follows: 1 horse-power of steam engine, applied to propel 6 tons of ship, is called a low or auxiliary power. Thus a ship of 600 tons, propelled by a steam engine of 100 horse-power, would have this proportion, and would probably do her voyage at about 8 knots an hour. A frigate of 3000 tons propelled by 800 horse-power would have a higher proportion of power to tonnage, or 1 horse-power to 4 tons, nearly, and she might do her voyage at 10 to 11 knots an hour, which would be esteemed good going. But if the best frigate in the navy were to attempt to go between New York and Plymouth at the rate of 14 miles an hour without stopping by the way, she would utterly and miserably fail, even if her power was increased to 1000 horse-power, which would be a proportion of 1 horse-power to 3 tons.

Now one would imagine that according to Sir H. Douglas's calculation, the "Great Eastern" had had two things—first, a much larger proportion of power to tonnage than the fastest ship in the navy; and, secondly, a much smaller speed. The facts which I now give Sir H. Douglas for his corrected calculation are the following. The tonnage of the "Great Eastern" is 22,500 tons; the propelling power is, rather overstated than understated, 2500 horse-power: the burden, therefore, of ship which each horse-power of engine has to carry is about 9 tons, being a smaller proportion of power to tonnage than any ship in Her Majesty's service. Nevertheless, with this *extremely small* power, the great ship has attained a higher speed than any ship of war of any power has ever attained in Her Majesty's service. What could Sir H. Douglas's calculations have been?

Seeing, then, that she has not disappointed my calculations, believing that she cannot disappoint Sir H. Douglas's corrected calculations, I next refer him to an authority which he will not dispute. Mr. Reed is a naval architect well known to Sir H. Douglas, and well esteemed by the whole profession of naval architects. He made and published a comparative statement of the theoretical performance of the "Great Eastern" as obtained by calculation, and the actual performance as given by his own observations. The following is this statement:—

"If we take the following quantities:—The speed, 15 knots; the midship section, 1600 square feet; the displacement, 17,500 tons; and substitute them in the two Admiralty formulæ successively, we get for the 'Great Eastern's' characteristic numbers, 750 and 316 respectively. Now none of the Admiralty vessels reach such numbers as these, but the very best of them fall considerably short of the 'Great Eastern' in both cases."

3. Sir H. Douglas's prediction.—*That 68-pounder solid shot would pass through the "Great Eastern" with tremendous effect.*

In noting the missiles which may be fired at a ship, and of the injuries inflicted which may be termed "tremendous," we may consider the following list:—

1. A 68-pounder gun, or 8-inch gun, can fire at a ship a great variety of missiles. First, she can fire red-hot shot, which, fired into a wooden ship, would stick in her sides among the timbers, and set fire to the hull of the ship in a manner nearly inextinguishable. This same shot would either not enter the "Great Eastern" at all, or if it penetrated her incombustible skin, would do no more harm to it than an ordinary bullet.

2. The 68-pounder gun can fire shells filled with molten metal, which, fired into the hull of a wooden ship, runs through all the openings among the timbers and planks in such a manner, that half-a-dozen such shells would be enough to disable and disorganise, if not destroy, the entire ship. The hull of the

"Great Eastern" would either resist altogether the entrance of such shell, or, if it entered, she would not be affected by it more than by a cold bullet, unless, indeed, on her wooden deck; an evil which might be remedied by making all her decks of iron, as some of them now are.

3. A 68-pounder gun can throw percussion shells and time-fuse shells, either of which, entering the side of a wooden ship, would explode in such a manner as to blow open her side, or to blow up her between-decks. According to Sir H. Douglas's Treatise on Gunnery, the explosion of such a shell on board a ship is the greatest danger she can incur, short only of the explosion of her magazine; all who know anything of modern gunnery are aware that it has the most tremendous effect known in warfare. These same shells, fired at the "Great Eastern," would, according to Sir H. Douglas's own statement, be deprived of all their explosive power, and could do no more harm than the accidents they might occasion wherever their fragments might strike.

4. The fourth missile of a 68-pounder is the common solid round ball, eight inches in diameter, which, passing through the "Great Eastern," would probably make one hole a little larger than itself on going in, and a second hole perhaps larger than itself on going out, and on its way through the ship it would probably kill any men that stood in its way, just as it would do in a wooden ship, and neither more nor less. Where, then, is Sir H. Douglas's tremendous effect?

4. Sir H. Douglas's belief.—*That the perforation in the outer shell could not be plugged.*

For my part, I believe what Sir H. Douglas says in another part of his "Treatise on Gunnery," where he actually gives a mode of plugging such perforations: not the best, it is true, though probably the best then known to him, though much better has been contrived.

From these four narrow premises, Sir H. Douglas draws this sweeping conclusion: "Ships formed wholly, or nearly so, of iron are utterly unfit for all the purposes and contingencies of war."

I now proceed to establish counter-conclusions upon facts.

5.—*Evidence of Experience against Sir H. Douglas.*

Experience of Captain E. P. Charlewood, R.N.	*Conclusions of Sir Howard Douglas.*	*Experience of Captain W. H. Hall, R. N.*
Q. You are a commander in the Royal Navy ?—I am. *Q.* Have you seen much service in iron and other vessels ?—My service afloat has been about fifteen or sixteen years ; about four or five years out of that period in iron vessels. *Q.* Did you subsequently command an iron steam-frigate in the service of the Mexican government ?—Yes. *Q.* The "Guadaloupe" ?—Yes. *Q.* With respect to iron as a material for building vessels of war, had you opportunities of forming any opinion ?—During the time that I commanded the "Guadaloupe," I certainly had several opportunities of forming an opinion as to its applicability for war purposes. With regard to strength, I have not a question in my own mind that they can be made considerably stronger than wooden vessels. I think that is a point which is settled ; and then, with regard to shot, from the various shot which strike a vessel, the damage was considerably less than is usually suffered by a wooden vessel, and I should also consider that there were nothing like the number of splinters which are generally forced out by a shot sent through a wooden vessel's side.	I stated that vessels constructed of iron are utterly unfitted for all the purposes of war. I stated that a shot striking with great velocity, would drive into the ship numerous splinters of the disc struck ; that the shot might break or impact, and its fragments, together with those of the plate, would drive into the ship a mass of splinters, consisting of pieces of the shot, bolts, bolt-heads, nuts, and innumerable pieces of iron, which	*Q.* You are a captain in the Royal Navy ?—I am. *Q.* Were you not promoted to that rank for services during the Chinese war ?—I was. *Q.* What ship did you command on that occasion ?—The "Nemesis." *Q.* What opinion did you form of iron as a material for vessels of war during the three years you commanded her ?—From the experience I obtained in China with respect to the "Nemesis," I formed a very favourable opinion of it. Several wooden steamers were employed upon the same service, and they were invariably obliged to lie up for repair, whilst I could repair the "Nemesis" in twenty-four hours, and have her always ready for service ; indeed, many steamers were obliged to leave the coast of China and go to Bombay for repairs. Repairs which would have taken in a wooden ship several days, would take in ours as many hours only. *See* Lord Seymour's Committee on Navy Estimates in 1848, p. 648. *Q.* Had you any opportunity of judging of the effect of shot upon iron while you commanded that vessel ("Nemesis") ?—In one action she was hit fourteen times ; one man lost his arm ; one shot went in at one side and came out at the other, it went right through the vessel. *Q.* Did you find that the shot striking the reverse side from within was of a dangerous character ?—Not at all. *Q.* In the case of that shot was there any splinters ?—No, it went through just as if you put

Experience of Captain E. P. Charlewood, R.N.	*Conclusions of Sir Howard Douglas.*	*Experience of Captain W. H. Hall, R. N.*
	would prove far more deadly and extensive than any shell, grape-shot, or case-shot.	your finger through a piece of paper. *Q.* Did the shot tear the iron away?—No, it made a hole and went out on the other side.
Q. How often were you under fire in the "Guadaloupe" (iron vessel)?— For four or five months, daily, I may say. *Q.* Have you been on board a wooden vessel which has been struck by shot?—Repeatedly. *Q.* Observing the effect of shot upon wood as compared with the effect of shot upon iron, do you see any marked difference?—I should say decidedly there is. *Q.* What is the nature of the difference?—It arises from the enormous splinters which I have seen torn from a wooden vessel's side, and on going below from seeing the few splinters which are thrown from an iron vessel's side. *Q.* As relates to splinters, do you think an iron vessel the safer of the two under fire?—I do. During the time I was on board the "Guadaloupe," she was hulled three or four times; she was hulled once in the midship part of the vessel at about 1000 yards; the effect was that it passed through the iron into the coal bunkers, making a round hole in the iron. *Q.* It made a round hole and not a large rent right and left?—No rent was made.		
Q. There was a shot fired after I left the vessel ("Guadaloupe") and of which the captain sent me the particulars. Two feet below the water, it passed through the vessel's side and through two or three casks of provisions. It was simply plugged by the engineer at the time, and after the vessel was out of action they put a plate of iron outside and screwed it to the place where the hole was.	That shot striking with reduced velocity, as from a distance, would make large jagged holes, that could not be plugged from the inside.	*Q.* You conceive that in all iron war-steamers facility would be afforded for stopping shot-holes?—Such is my impression. Nothing could be more easily stopped than I could have stopped that hole in the "Nemesis."
Q. Did any of those shots	That shot strik-	

Experience of Captain E. P. Charlewood, R.N.	*Conclusions of Sir Howard Douglas.*	*Experience of Captain W. H. Hall, R. N.*
displace the rivets?—None while I was on board. *Q.* Did it disturb any of the rivets which fasten the plates of which the frame is formed?—It did not.	ing a rivet or rivets, as at the junction of four plates[*] they might do, would make a large breach in the side of the ship.	

Captain Hall, R.N., gives as the results of his experience in the iron ship "Nemesis," "on another occasion the shot struck the ship's side outside obliquely and *glanced off.* It *glanced off altogether,* making an indent in the iron. I think if the vessel had been built of wood, it would not have glanced off."

It may be said, that these shots were not the heaviest shot that could be fired: to which I answer that the "Nemesis" was not the strongest vessel that could be built to meet the shot. She was a vessel of light draft, not originally designed for the purposes of war.

Although Sir H. Douglas has collected a large number of experiments upon iron plates, for the publication of which we are much obliged to him, yet the great bulk of these experiments are, from the negative character of their results, of very little practical value, and those that are valuable lead to conclusions entirely at variance with those which Sir H. Douglas has endeavoured to deduce from them.

A multitude of these experiments have been made on steel plates, cast-iron plates, and various compositions of plate, in regard to all of which the conclusion is, that they were not effectual to resist shot.

But Sir H. Douglas has not the slightest ground to deduce from the failure of these improper materials any conclusions whatever in regard to the proper materials. If twenty substances did not answer the purpose, surely that is not the slightest argument against the twenty-first which did. The simple fact regarding these experiments stands thus:

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[*] Sir H. Douglas's want of acquaintance with the structure of iron ships, led him into this error of supposing that there would be a junction of four plates. Four plates joined together at one point would be so obvious a source of weakness, that the arrangement would not be adopted in practice, care being always taken that where two plates join, the two adjacent plates should not join.

A multitude of plates of unfit materials were set up as targets and broken.

That a few which were formed of the right materials and the proper dimensions did resist the shot to an extent which renders the protection of iron sides much greater than wooden sides, leads us to the only conclusion that is of any practical value; and the real solution of the question at issue depends not on the multitude of injudicious experiments, but on the few comparatively successful ones. Thus we learn what to follow and what to avoid.

Sir H. Douglas tells us that the manner in which the experiments were conducted on which he relies, was thus: "at Portsmouth the practice is invariably made by firing *at the same spot* until the plates have been breached."

We will concede at once to Sir H. Douglas even more than he asks. We will concede that a plate of hammered iron of *any* thickness fired at continually "*on the same spot,*" will in the end be more or less damaged by it, for we know that a drop of water by continual falling will wear a hole in a stone; but we will ask Sir H. Douglas one practical question—what are the chances in a naval engagement for a ship being struck three times on any one spot?

Sir H. Douglas has therefore mistaken the issue of the argument about iron plates. I will now venture to put it in as concise a summary as I can.

1. The facts we have ascertained about them with tolerable certainty are the following:—The experience of Captain Hall and Captain Charlewood in ships of iron actually engaged in war has shown, first, that even where the thickness of the vessel's side is not more than half an inch, shots fired obliquely have glanced off the iron vessel which would have penetrated a wooden ship; second, that shots fired directly have passed through both sides of the ship, doing less damage to the ship directly and less damage by splinters than would have been the case in timber ships; third, that the shot-holes have been as easily stopped, and more

expeditiously and less expensively repaired than in wooden ships; fourth, the experiments quoted by Sir H. Douglas have shown that "thin plates of wrought-iron, even five-eighths of an inch thick, are proof against shells;" "that plates two inches thick are impenetrable, even to the pieces and fragments of shells;" "that iron plates four inches and a half thick are nearly impenetrable to shot fired from the heaviest nature of guns;" and, finally, that plates six inches thick are practically impenetrable.

II.

ON THE COMPARATIVE ADVANTAGES OF IRON OVER WOOD, IN BUILDING STEAM-SHIPS OF WAR.

I HAVE already shown that Sir H. Douglas has failed in the proof of the conclusion he undertook to establish, that ships formed of iron are utterly unfit for the purposes and uses of war.

If this had turned out true, we should have been left without an alternative, in case our wooden walls had proved (as they have done), utterly incapable of resisting for more than a very few minutes the powers of modern artillery and ammunition. It is now admitted by the experienced naval officers with whom I have conversed, that a close engagement between two ships of the line must be a question merely for five minutes as to the total destruction of either or both. It is certain that five rounds of modern missiles, well delivered from forty guns on the broadside of a first-rate, will have finished the action.

The practical conclusion from this state of things is, that such an action has become impossible; and therefore, if no better means of defence had been discovered, wooden walls have ceased to be an effective defence.

The question has therefore arisen in these days—why not use iron?

Against the use of iron for war-ships, and even for any ships at all, the most inveterate prejudices have long existed in the minds of sailors, ship-builders, and all who have made naval affairs their occupation. It is only the slow growth of intelligence, and the gradual formation of practical experience of the great benefits to be obtained by the use of iron, that has been strong enough to overcome some of these prejudices, and slowly, painfully, one by one, they are now becoming eradicated.

It was only however in 1854 that the final blow was inflicted by the Emperor Napoleon on the prejudices of our naval men against the use of iron for ships of war. The fact, as it turned out, was the following:—

1. It was proved by the attack of all our fleet on the forts at the entrance of Sebastopol, that it was impossible for our wooden walls to succeed in the reduction of land forts, even with an overwhelming force of artillery.

2. It was proved at Kinburn that the iron batteries of the Emperor were shot proof, and that they succeeded in the reduction of land forts without themselves incurring any serious damage.

This decided the subsequent course of French policy, and iron was at once adopted by the Emperor as the suitable material for his future fleet, both of large ships like the "Gloire," and of small gun vessels for shallow draft of water.

The facts given above which decided the Emperor's policy served merely to give indecision to ours; and during all these years we have kept on spending millions on our wooden walls through pure indecision.

The following is a summary of the facts which experience has one by one established, and the prejudices which it has one by one painfully rooted out.

PREJUDICE No. 1.—*Iron cannot swim.*

A good many years ago I happened to converse with the chief naval architect of one of our dockyards, on the subject of building ships of iron. The answer was characteristic, and the feeling it expressed so strong and natural that I have never forgotten it; he said, with some indignation, "Don't talk to me about iron ships, IT'S CONTRARY TO NATURE." The naval architect was quite right, it is contrary to nature, because iron is eight times heavier than water, and water will carry only its own weight, or a weight lighter than itself bulk for bulk. Wood on the contrary is generally lighter than water, and fir-wood nearly half the weight of water, so that iron really is from ten to twelve times as heavy as wood. Iron therefore cannot and ought not to swim, it is contrary to its nature as a material to swim. It is of the nature of iron to sink as it is of wood to swim.

But it is as a brute material only that iron cannot swim. An iron ship is a work of art, and of the highest art; and just as brute iron is not a locomotive engine, so brute iron is not a ship, and the disjointed pieces of the iron of the ship are no more able to swim than the disjointed fragments of a locomotive engine are able to run themselves along a railway.

An iron ship is therefore a victory of art over nature, and the manner in which iron is made to swim is a triumph of science and mechanical skill.

How iron swims. Iron is not only ten times heavier than oak and eight times heavier than water, but it has the advantage of being ten times as strong. It is this strength which enables it to be turned to the purpose of swimming, and to swim in the water even lighter than wood.

The art of making iron swim consists mainly in this, in spreading it out in a thin layer over a very large space so as to exclude a great deal of water and to inclose a great deal of air. By this means an iron ship weighing 1000 tons, but containing as much more air in its bulk as its own weight is greater than an equal weight of water, the air and the iron together make up a bulk which is lighter than the same bulk of water, and so the bulk floats the iron, and the ship swims just as a blown bladder would swim.

Thus it becomes possible for an iron ship to swim because it contains enough bulk to buoy it up. Fill it with water instead of air, and it would at once sink to the bottom. The two conditions of iron swimming therefore are, enough room within and enough water without. It follows from this also, that the bigger an iron ship is the easier it is to make it swim, and in practice it is the fact that it is much more advantageous to make a large vessel of iron rather than a small one.

PREJUDICE No. 2.—*A ship of thin iron plates cannot be as strong as a ship of thick wooden planks.*

Iron being then ten times heavier than wood, that wood being the best oak, it follows that an oak plank 10 inches thick and an iron plate 1 inch thick will have the same weight. Suppose then the planking of the outsides of a wooden ship to be 5 inches thick, the outside iron planking of an iron ship half an inch thick, that would be of the same weight. We are therefore to remember that half an inch and 5 inches are the numbers which should rule in comparing iron and wooden ships together.

But it is not the intrinsic strength of the piece of iron as compared to a piece of oak which tells most in the strength of a ship. The ship is built in pieces which are numerous, and comparatively to the whole ship, small. A vessel of 1000 tons contains probably 2000 principal pieces of timber in her hull, and the difficulty of building a good timber ship is the difficulty of joining those pieces together by means so strong and powerful as to resist the efforts of a storm at sea.

Now the main difference between the great strength of an iron ship and the comparative weakness of a wooden one consists in this, the *manner of joining the pieces.* To illustrate this, take two rods of wood and try to make them into one—you cannot succeed, they will never unite; but take two bars of iron and put them into the fire, and you can thus weld them as perfectly into one as if they had originally been a single bar. Many of the great beams which cross the Great Ship are formed in this way, by welding three or more pieces into a perfect continuous iron bar; and neither the eye nor force could show the junction to be less perfect or less strong than any other part.

This is a great advantage for iron which wood does not possess. Two beams of wood cannot be welded, and all we can do to join them is to take a third piece of wood, as strong as either of the two, and fasten it across the junction; fastening it so firm to both parts, that in order to sever them this third beam must be broken. This is called a splice or a scarf. This third beam is so much timber thrown away except in as far as it strengthens them, and it follows therefore, that at every joint of two pieces of timber, there must be a third having nothing to do but to join them.

So much for joining the ends of bars and beams together. Let us now consider the joining of the edges of wooden planks together, and the joining of the edges of iron plates together. The edges of two adjacent iron plates can be riveted to each other, or, as it were, *sewn* together in such a manner that the seam is very nearly if not quite as strong as where there is no joining. Generally speaking, however, it is not quite so strong, losing about one-fifth of its strength by the holes made for the rivets ; but in wood how can two planks be sewed together? On a small scale they can be glued, and it was at one time imagined that the famous substance called marine glue was the desideratum which would join two oak planks together and make them one ; unhappily to this day no method is known of combining into one two separate planks.

How then are the planks of a wooden ship actually kept together? Answer—by the same sort of expedient by which the ends are kept together. A second set of wooden planks or timbers are laid across this first set, and sometimes a third set laid over these ; so that the strength of one set at right angles to the other set may serve to bind their edges together ; and so it may still be said that one half of the parts are doing no service except helping to keep the other half together.

The reader will now understand why in a wooden ship nearly all the parts go in pairs. A single rib or frame of an iron ship is a continuous bar bent round to the shape of the ship. In a wooden ship each rib or frame as it is called, consists of two entire ribs or sets of timber joined together ; and each rib consists itself of a number of pieces, but the two sets are so arranged that the joints in the one come opposite to the whole places in the other, and so when joined together the two become as good as one. These form the transverse frames or ribs which run across every part of the ship, but to unite them we have an entire series of pieces of wood outside, forming what is called the planking.

I think I am not far from the vulgar truth then when I say, that half of the entire timber in a ship is merely occupied in strengthening the butts and closing the joints of the other half, whereas the waste in an iron ship will not be one-tenth.

Not only are the modes of uniting the pieces more perfect in iron than wooden ships, but the individual parts and pieces can be made of much greater strength. Single pieces of iron can be manufactured of any size, in any shape, that human ingenuity can devise. Wood chooses to grow in its own size and shape, and its form cannot be changed without loss of strength. Iron can be turned round any corner however sharp without breaking. This is to iron ships another great source of strength. But these advantages which are true on a small scale become true in a different degree as the size of the ships increases.

A large ship built of wood is much weaker than a small ship built of wood. The reason of this is, that wood being grown, the pieces of which it is composed cannot be got proportionately larger as the ship is larger. Thus the planks of a small ship may be a foot wide and thirty feet long, but planks for a ship three times the dimensions, could not be found three feet wide and ninety feet long, and this holds all through the ship; the bits of which it consists are a multitude of small pieces, more multitudinous and smaller in proportion as the ship is larger. This is a great source of weakness in a large ship. The iron plates on the contrary, of an iron ship, can be made of a size proportioned to the size of the ship; and the strength of a piece of iron as of a piece of wood increasing in a high ratio with its size, the iron ship is composed of a comparatively small number of very large and very strong pieces, while the wooden ship is composed relatively of very many very small and weak pieces.

PREJUDICE No. 3.—*That an iron ship will sink deeper in the water than a wooden one.*

Precisely the contrary of this is the truth.

Take for example one of the largest frigates in the navy. Say the new "Orlando" class. The weight of her hull is 2500 tons. The weight of an iron ship of equal tonnage is 1500 tons.

Iron ship weighs 1500 tons—wooden ship 2500 tons.

Now let us put equal weight into both ships; an equipment say of 2000 tons. The total weight of the iron ship is 3500, and of the wooden 4500.

Now the principle by which ships float is this, that other things being equal, the depth to which things sink in water are exactly in the proportion of their weights. If then the wooden frigate with her equipment sink to 21 feet in the water, the iron frigate will only sink to 17 feet, and this difference between 17 and 21 would enable the iron ship to carry 1000 tons of coal, or anything else on the same draft of water on which the wooden vessel carried none. If now we put an additional 1000 tons of coal into each, we should have the "Orlando" drawing 23 feet water, and the iron frigate 23 feet water, but with 2000 tons of fuel instead of one.

The facts then are, that with equal size the iron frigate draws less water, and with double the supply of fuel, equal water with the wooden one.

PREJUDICE No. 4.—*That iron ships cannot carry so great weight as wooden ones.*

We have just seen that the weight of the hull of a wooden ship of the largest class amounts to 2500 tons, and of an iron one of the same strength, 1500 tons; that this difference of weight can be carried in useful loads,—in other words, that on an equal draft of water the wooden frigate can only carry an equipment and stores amounting to 3000 tons, while the iron vessel can carry 4000 tons.

I will take one illustration more. The "Great Eastern" is a vessel of 23,000 tons burden. The largest class of frigate is a vessel of 3500 tons burden. The hull of the "Great Eastern" weighs less than 8000 tons; the hull of the "Orlando" more than 2500. For each ton of size, therefore, of the "Orlando" we have five-sevenths of a ton of weight of hull; for each ton of size of the great ship we have less than three-sevenths of a ton of weight of hull.

Yet it is universally admitted, that the "Great Eastern" has proved herself to be the strongest ship in the world, having been subjected to strains in the act of launching, no other ship ever endured with impunity. On that occasion only 240 feet of her length were supported, the whole of the remaining 700 feet of her length being unsupported; and that not for an hour or a day, but throughout long months of torture, and yet no eye could detect, and no instrument appreciate, any sensible quantity of flexure.

It therefore appears that the weight of the "Great Eastern" occupies only 8000 tons of her carrying power; and as she is able to carry no less than *thirty thousand tons,* this leaves 22,000 tons available weight for equipment, coals, and cargo.

Is it further necessary to show that iron ships can carry greater weights than wooden ones? I may add, that a wooden steam-ship of the size of the "Great Eastern" could not carry her own weight.

PREJUDICE No. 5.—*That iron steam-ships are less safe against the perils of the sea.*

This grows out of Prejudice No. 1, that it is against nature for iron to swim; and I will frankly grant at once, that when the parts of an iron ship are broken up by the force of the sea, if the ship goes in pieces, the pieces of the wooden ship swim while the pieces of the iron ship sink.

But for this difference, which I admit, there is a compensating difference in point of safety that far outweighs it. This advantage of the iron ship over the wooden one lies in the method of construction. This method is one which has not always been sufficiently adopted, but one which I have long advocated, and of which I have shown the example perhaps more than any other builder. I mean the system of extensive sub-division into separate water-tight compartments. I have divided the "Great Eastern into eleven of these transversely, and into double that number longitudinally. Into each of these water-tight compartments a large hole might be driven without compromising the safety of the rest of the ship. Into any of these the stem of another ship might run, without damaging the rest of the ship, and half-a-dozen of them could be filled with water without a single passenger suffering inconvenience. An explosion did take place in one of them without affecting the safety of the rest, and without even stopping the machinery of the ship.

It is enough to say, that this method of construction is a peculiarity of iron ships, unsuited to wooden ones.

Against this Sir H. Douglas brings such examples as the "Birkenhead" and the "Royal Charter." Now Sir H. Douglas knows, or he ought to know, that the first of these vessels was defective in having too few of these water-tight compartments; and that the "Royal Charter," besides being of a bad shape, had few of the transverse compartments, and none of the longitudinal bulkheads, which alone could give to a vessel of that size adequate strength and safety. But it is absurd to infer that, because bad vessels can be built of iron, good ones are therefore to be placed in the same category. In fairness Sir H. Douglas should only compare the best iron with the best wood.

(6). *Comparative safety in case of fire, of iron and wooden ships.*

When we consider the enormous quantity of red-hot fuel continually blazing in the boilers of a steam-ship, and that, in fact, there are many tons of red-hot fuel within a few inches of the wooden skin of a timber steam-ship, the surprise will be that any amount of care should ever have preserved her from fire. It would, therefore, appear that no argument was necessary to prove the greater safety of an iron ship from fire; and indeed they would be absolutely fire-proof, excepting that some wood continues to be used in their construction, and that a large proportion of the materials they may happen to contain may be combustible. The finest example on record of safety in a ship is that of the iron steam transport "Sarah Sands," which caught fire at sea, while carrying a full complement of troops to India. Her contents were entirely burnt out for about a third part of her length, her magazine exploded, yet she was saved; not a life was lost, although she encountered a gale of ten days' duration after the accident. To this experience there are many parallels in iron ships. We defy Sir H. Douglas to produce one such in wooden ships. That iron ships are, therefore, much safer against the ordinary accidents of fire than timber ships, we may almost consider an axiom.

(7). *Comparative resistance of iron and wood to red-hot shot.*

That there should be a moment's question upon this subject seems almost waste of time. The employment of red-hot shot against wooden walls, was an obvious way of setting fire to these walls, and was therefore extensively put in practice. They stick in the sides of the ship, producing smoke and flame, and, in great numbers, were sufficient to set the ship on fire. It is self-evident that even if they could lodge in the hull of an iron ship, they could not set it on fire.

(8). *Comparative resistance of iron and wood to shells of molten iron.*

The red-hot shells mentioned in the previous paragraph, when lodged in the hull of a ship above the water, could often be got at, and extinguished with buckets of water. A much more deadly and inextinguishable way of setting a ship on fire was accordingly contrived in the molten iron shell.

The nature of this missile is as follows:—A hollow ball of cast-iron, 8 inches in diameter, is filled with some 40 or 50 lbs. weight of melted red-hot iron. This is fired into the side of a wooden ship, on striking which the shell breaks in pieces, and all the molten iron escapes in every direction, and especially getting in between the timbers which form the frame of the ship, and between which large channels are left, through which it penetrates into the very heart and substance of the whole construction, the ship is thereby set on fire, generally inaccessibly and inextinguishably. The invention of this missile is probably the stone that has broken the camel's back, for up to the time of its successful introduction, men of high naval experience and knowledge continued to believe that a wooden ship of the line might be successfully fought against modern missiles; but a ship of the line, everywhere on fire, to her very core, with molten metal running through all the interstices of her frame, is a structure which even British sailors can hardly be expected to keep to; and you can now find few practical and well informed men who will seriously propose that you should leave a thousand sailors to be burnt out like bees smoked in a beehive.

It is only necessary that a ship should be entirely built of iron, and these shells may be delivered on her sides with no other effect than to run off her hull like so much water. On this subject no further reasoning can be necessary. It is the conclusive defeat of wooden walls, and the certain inauguration of iron.

(9). *Comparative resistance of iron and wood to time- and percussion-shells.*

Two kinds of shells hold an important place in modern warfare. Those which explode in a certain time after being fired, which we may call time-shells, and those which explode on hitting the object, which we may call percussion-shells. The nature of both can be easily understood. Those fired from a 68-pounder gun consist of a round hollow ball, eight inches in diameter, filled with gunpowder; these are fired like any other shot from the 68-pounder gun, and embed themselves in the side of a wooden ship, where they lie until the time comes when they are to explode. When they burst in the side of a ship, they generally make an opening about the size of an ordinary door, and a broadside of such shells, well planted, would simply blow out the side of a ship.

Now it has happily been discovered, that on the skin of an iron ship these shells are broken to pieces, the powder flies out like so much dust, and therefore THE SHELLS NEVER EXPLODE. The fragments of iron do no more mischief than if they had never formed any part of a shell, and are just as much or as little innocuous as any other fragments of iron would be.

It was the discovery of molten shells that put an end to wooden walls; but the discovery that shells were shattered to pieces by iron, and their explosive power taken out of them, was the crowning fact which made the victory of iron complete.

Shells are therefore the chief missiles of modern warfare, and a battery engaging a wooden ship of any size would, as a matter of course, pour into her broadsides of molten iron and explosive shells. It is believed that one round of molten iron and one round of percussion shells well delivered into a first-rate wooden man of war would destroy her; that the action would probably last three minutes (not more), and that in five minutes she would be a blazing and sinking hull. Such would be the victory of artillery over wooden walls.

Iron has restored the equilibrium between attack and defence. It has done more even than that. It has turned the scale against artillery; for shells cannot effectively penetrate the sides of iron ships, and shells are by far the most destructive missiles of war.

(10). *Comparative resistance of wood and iron to solid shot.*

We come last to the question of common iron solid shot, the old-fashioned missile used in the old naval engagements, before modern artillery with its shell-guns of large calibre came into use, and before Paixhans, Dundas, Boxer, Whitworth, and Armstrong had given to artillery its recent extension. So long as naval engagements were confined to solid shot, very little mischief was done. Shot penetrated the sides of a ship, disabled a mast, a rudder, or a gun, passed through and through the ship, killing the few men who happened to cross its path; but the carnage was moderate, and ample time was given for the exercise of judgment, skill, seamanship, personal adventure, and all the virtues of a British seaman. On a first glance at the question of iron ships, it would appear therefore that iron has merely restored the old-fashioned balance between ships and artillery, if it has succeeded merely in excluding from the interior of the ship the wholesale destruction of the modern shell. To preserve our sailors from this speedy destruction, and give them once more a chance for victory by skill and bravery, would be a great boon conferred on the

British navy by iron ships, even if the solid shot was still to penetrate and pass through their hulls, as it did through the wooden ones; but experience has proved that the iron not only keeps out the shells, but in certain circumstances the shot also. At small angles, such as the bow of a fine iron ship presents to the guns of an enemy on which she is bearing down, the shot is deflected altogether and turned aside. Iron plates less than an inch thick, do this effectually. For angles less sharp, a greater thickness will still suffice to turn aside the shot. At still greater angles three inches suffice to turn aside the heaviest shot, and iron plates properly employed as armour 4½ inches thick have been nearly sufficient to stop altogether and keep out the heaviest shot fired with the highest velocity from the nearest practicable distance, and only a very few shot in exceptional circumstances have ever passed through a sound good iron plate 4½ inches thick. And when we go to six inches thick of good tough wrought-iron, there is no one practically acquainted with the subject who has ventured to suggest even that such a plate could be destroyed in actual warfare by a blow from any known projectile. This fact of the progressive impenetrability of iron plates from three-quarters of an inch which keeps out all shells, to four, six and eight inches which practically keeps out all shot, is the fundamental fact on which the iron fleet of England has yet to be constructed.

III.

THE FUTURE FLEET OF ENGLAND.

Out of the series of facts we have stated above, there arises a great necessity, which at the present moment becomes to us a national emergency. It has been made certain that our ships of the line, with their 91 guns, and their 950 men, cannot survive a cannonade of molten metal and explosive shells for five minutes, if well directed. That a wooden ship of any kind will be almost immediately exploded or sunk by the unerring aim and irresistible power of our Armstrong and our enemy's rifled guns, is a conviction we cannot avoid, and the consequent inutility of our wooden walls is a conclusion that we cannot evade.

What, then, is our future defence? What is our future navy? In what will it resemble, and in what will it differ from, the fleet of the past? How shall it be constructed? How long shall we remain defenceless without it? What will it cost, and when can it be completed? Who is to design it? Who is to execute it?

The re-construction of the British navy is, indeed, a problem in itself impossible to contemplate without serious anxiety and deep concern. This feeling is increased by the consideration that we have no longer time for thought, because the moment for action has already arrived. Unhappily, the long years for preparation which were given us have been wasted. The foresight we might have exercised, the experiments we might have made, the designs we might have matured and improved and multiplied for the future day of difficulty might have been, and are not; and now the day has come when they are wanted, and the result of the indecision, or blindness, or obstinacy, or infatuation of those who would not be warned in time, is that they are now called upon to act at once, even at the peril of not being able to think.

It may, however, be a good introduction to the consideration of what now should be done, to consider carefully what ought to have been done; because we may find that exactly the same obstacles which prevented our doing right in time, may prevent our doing right even now that the moment for action has arrived.

What has hitherto been done about iron ships? For the last twenty years the substitution of iron for wood, in the construction of merchant steamers, has gone on with a rapidity astonishing even to those who were its warmest and earliest advocates. Twenty years ago, not a twentieth part of the steamers of England were of iron. To-day, not one steamer in a hundred, now being built for merchant owners, is of wood. I mean sea-going ships—not river-boats. One would have imagined that this fact alone, in continued and steady progress, under the eyes of the British Admiralty, would have led them speedily to avail themselves of every advantage that iron could offer. It was as easy for them to have discovered then, as now, what thickness of iron plates, and at what angle, would be sufficient to turn aside a shot and to shatter a shell.

It appears that they felt so themselves. They felt that ugly questions were being asked of them on this subject, and that something or other must be done to silence the people out of doors, who were wanting to know, why the Admiralty would not avail themselves of the many obvious advantages of iron in the construction of steamers of war.

Accordingly, an experiment was made, and made in such a way that the conclusion they desired to arrive at might be effectually secured, and inconvenient questioners authoritatively pu
down.

An old, worn-out river-boat, of thin and decayed iron, wa
accordingly procured; it was set up as a target, and fired at with heavy artillery and triumphantly demolished.

This much information was at least obtained, that old iron could be demolished by artillery, and there the matter ended; and the authorities retired from the performance, justified in their reluctance to assist in the introduction of a troublesome innovation.

This trial answered for a while, and in these few years iron was still making progress, and getting itself introduced more and more successfully into merchant practice. It was becoming established, by daily experience, that iron ships were stronger than wooden ones, did stand greater fatigue on long voyages than wood, and did require less repair.

A new Admiralty came in, with fewer prejudices than their predecessors, and with less reason to follow their precedents. This new Admiralty, determined that iron should at least have a trial, and determined wisely that a frigate, or frigates, of iron should be fairly built and fairly tried.

The fate of this Admiralty, and of its iron experiment, is well known. Wood and its supporters were too many for them. They built their iron frigates and they were turned out. The opponents of iron were now in power. Determined that the iron frigates should not succeed, they also determined that the surest way to prevent their success was, that they should never be tried; and so, some ten or twelve years ago, a fleet of iron frigates was designed, ordered, built, launched, paid for, but never armed, never fitted out for sea, and never tried.

Thus the most noble and costly experiment upon iron was made, was never turned to any account for the country, and the vessels were either sold, or turned to other uses, and sent out of the way, so that iron should, if possible, never have a chance in the navy of Great Britain.

Iron, however, was not to be put down, and in various ways, most inconvenient to its enemies, it has year by year kept popping up its head. It at last found a patron. The Emperor Napoleon took its part, and determined that he at least would give it a fair chance. Happily he was strong enough to be his own First Lord of the Admiralty. He ordered not only that iron should be tried, but that it should be so tried that it should succeed. He ordered the iron batteries to be constructed and to be used. We were obliged to content ourselves with a simple copy, which we ignominiously made, and in making which we as ignominiously failed. We were not in time, but the Emperor was, and the capture of Kinburn was his reward.

But even we did something in iron in the Crimean war, but rather by a sort of backdoor than directly. We bought, or rather bartered, two iron gun-boats, the "Recruit" and the "Weser," which had been built not for our Admiralty, it is true, but for a foreign Admiralty, although by an English shipbuilder, and for this unusual enlightenment we, too, had our reward; for it was our iron gun-boats which, in the sea of Azof, captured and destroyed all the Russian stores at Arabat, and thus helped materially to conclude the war.

Happily, however, the war ended, and the Admiralty were able to return to the completion of their wooden walls. The victory of iron was complete to those who would see it, but to those who would not see it, no proof was enough. Clear-sighted men, in the navy and out of it, knew the virtue of iron, and urged on the Admiralty its use and adoption on this side of the Channel in vain. But on the other side of the Channel, clear-sighted men saw what was best to be done and were allowed to do it.

Meantime it was not permitted to our Admiralty to be altogether idle. Troublesome people kept urging the question of iron, and the Admiralty kept contriving how "not to do it."

The contrivance was very clever. To seem to do it, to be at great pains setting about it, but never to do it. For this purpose diligent experiment was considered to be the aptest expedient. "Let us contrive experiments in which the iron shall have the worst of it." "Let us expend our ingenuity, not in making experiments how to make iron successful, but in making experiments to show iron to be unsuccessful." This they did with such indefatigability and ingenuity, that out of the multitude of experiments against iron plates, it was found possible to break, penetrate, or damage most of them.

Unhappily for the wooden advocates there were one or two occasions on which the iron, despite of all ingenuity, did turn out successful. This was unlucky; for the common sense of men soon led them to conclude that, if there was one good way in which iron could resist artillery, the hundred and one bad ways went for nothing in the question.

It was an unlucky day for Wooden Walls when Captain Halsted and the "Trusty" were attacked by Armstrong's largest guns and his heaviest steel bolts. That day the opponents of iron suffered a terrible defeat. The iron plates of the "Trusty" were found to be, practically, shot proof. The intentions of the wooden party had been that the "Trusty" should not have fair play —that she should have foul play.

Unluckily, Captain Halsted was there. He saw that the "Trusty" had fair play. The "Trusty" deserved it, and came out of the trial triumphant. She could be damaged by shot; could be injured by steel bolts; was the worse for the Armstrong guns; but was practically, and for purposes of war, invulnerable. To this conclusion came every practical man who saw the experiment, and every practical man who, like myself, examined the effect of those iron plates upon the shot. To have seen, as I have, a long steel bolt, fired as an elongated missile from Armstrong's gun, squashed up endways, like a bit of clay, on the iron armour of the "Trusty," was to be convinced that iron vessels, mail-clad, like the "Trusty," were too strong even for the Armstrong artillery.

But although the "Trusty" was too strong for Armstrong steel-bolts, the advocates of wood continued to launch the shafts of their arguments against her. "Was it not proved," they said, "that her armour had joints, and that the joints were weak?" This was at once admitted, but what then? It only showed that the joints should be strengthened. But again say they: "In iron ships you must have ports; these ports are openings through which both shot and shell may be fired into the ship."

This also must be admitted, and what is the conclusion? Why, that your ports should be as small as possible, and that you ought to contrive them so that they may be opened as little as possible, and as short a time as possible, without interfering with the practice of your artillery.

And now comes a plain practical question. Grant, if you like, that no thickness of plate can render an iron ship invulnerable. Does any practical conclusion grow out of that unfavourable to the use of iron-coated ships instead of the much more vulnerable wood? Is the practical question now under consideration not this? Whether are iron-plated ships or plain wooden ships the more effectual engines of war? Will you grant that an iron ship will stand ten minutes hammering, while her wooden opponent will only stand five? Will you grant that all the red hot shot and molten metal shells and explosive missiles, which the iron vessel fires into the wooden one, will set fire to, and explode, and burn to the water's edge, or sink her wooden antagonist, while all the same missiles fired from her will fail to burn, or explode in, or even enter her enemy? Because if you do this, you concede all we want, and we will give you, for argument's sake, the consolation of believing that some of the shot-bolts will find their way through the joints of the harness and do some harm.

But even in this too much is granted against the iron. What is true and may be frankly conceded is, that every time you strike a ship coated with iron armour, quite fair with a steel bolt, you will do some damage; you will scratch the plate, or crack it, or indent it, or widen a seam, or knock off a corner of a plate, and if when you have done this once you can strike the same joint a second time, a third time, and a fourth time, you may by continual hammering ultimately harm the plate, break it to pieces, knock in its fragments: and in the end, giving you plenty of time, an inexhaustible arsenal of missiles, a quiet sea, and no one to trouble you, you will damage the ship and ultimately make her a wreck. There is but this difference between the two, that what it takes hours to do to the iron-coated vessel by the wooden one, will be done in minutes to the wooden ship; that is all—hours against minutes.

WHAT IS TO BE THE FUTURE FLEET OF ENGLAND, AND HOW ARE WE TO SET ABOUT ITS CONSTRUCTION?

If any men were at the present day to recommend that all the earthworks and granite defences of a fortified city, were to be levelled with the ground, and that the city should be surrounded by a wall of timber thirty inches thick, and thirty feet high; and that on these wooden walls the security of a capital and the liberties of a country should be defended, from an enemy possessing all the science, skill, and implements of modern warfare, the man would not be reasoned with for a moment. The comparative value of granite, earth, and wood in military warfare, are too well known to admit a moment's doubt on such a question. There is another question, about which there remains no more doubt in the minds of the best informed, although the multitude are not as yet aware of the fact; that iron is for purposes of defence, even more effectual than granite and that wherever practicable, the one is now being substituted for the other.

Am I to suppose that Sir H. Douglas was aware of this fact, or was not aware of it? He admits everywhere, or rather advances prominently, the fact that he is in the confidence of the naval authorities, who assist him with every kind of official information. Did the proper authorities inform him, or did they not, that one department of Government had satisfied itself so entirely of the superiority of iron over wood, brick, granite, and every other substance, by practical experience, that they had determined to form all the embrasures of their casemates of iron, and had introduced them into all their designs and specifications for our new fortifications. I do not profess to be in the confidence of either department, and therefore I am perfectly at liberty to inform Sir H. Douglas, if he did not know it, that such is the fact. Experience has shown that granite cannot be trusted against the modern artillery in the immediate vicinity of the gun; and that iron, without the slightest backing of wood or any other substance, is the only secure material behind which men can now be asked to work their guns. Would Sir H. Douglas recommend wood embrasures in granite forts as a substitute for iron in our fixed batteries, as he does in our floating batteries?

Putting these facts together, how can we possibly entertain the belief that the safety of England can be confided to *her* wooden walls, if it can be ascertained that a fleet can be built of iron, that the iron can be rendered shot-proof, that it is known to be fire-proof and shell-proof, and that with these qualities, which wood cannot have, it may also be as safe, as seaworthy, and as fast as any wooden ship that ever was built?

Each of these points we have already proved to be in certain circumstances absolutely true; and the question now remains, how are we to construct all the various classes of which a fleet must consist, so as to possess these various qualities in their several proportions and degrees? This task we now undertake to perform.

CLASS NO. 1.

The New Iron Steam-Ship of the Line.

What is this first-rate to be? Is it, like the "Duke of Wellington," to carry guns on four decks, on three decks, on two decks, or on one? Is it, in short, to be a copy magnified or not from the "Duke of Wellington?" This is a large and vague question, to which, at first sight, the answer is anything but obvious. Nevertheless, the question carries in it its own answer.

No one denies that the speed of the new first-rate must exceed the speed of any vessel heretofore constructed. Speed implies choice of time for action. Choice of time implies also generally choice of place for action. Give to an admiral choice of time and choice of place, and he must be a sorry commander, indeed, who cannot win you the battle.

The next point in the new first-rate is one less obvious. Are to be satisfied, short of a theoretical absolute impregnability for our ship? Or shall we be content with such reasonable and moderate impregnability as will bring back the sailors' risk to something like that of an old sea-fight? In making this choice, it will easily be understood how important it is when I state that on this choice depends whether our ship is of the size of 6,000 tons, like the "Warrior," or of 10,000 tons, being nearly half the size of the "Great Eastern;" for this absolute impregnability we must pay more than for the practical impregnability aforesaid in the proportion of six to ten.

The next point is the amount of armament which it is desirable to carry in any single ship. If the new first-rate is, like the old one, to carry 100 guns, she inevitably becomes of the following size: 10,000 tons burden; her cost, fully equipped and armed, is £750,000. Her speed will be fifteen knots. She will have 2,500 horse-power, and she will be in all respects a thorough sea-going ship. She will carry fuel for 5,000 miles.

CLASS II.

The New Iron Steam-Frigate.

If she is to be capable of co-operating with the new iron first-rate, the new iron steam-frigate will have to be a little larger than the "Warrior," for the "Warrior" has the fault of having been built too heavy in her materials, so that she cannot carry fuel enough for a sea-going voyage. She must be 7,000 tons, instead of 6,000. She will then carry fifty guns, instead of thirty-six, and will be in all respects a thorough sea-going vessel, capable of being sent to, and remaining in, any part of Her Majesty's dominions. She will have a speed of 15 knots. She will also have fuel for 5,000 miles. This improved "Warrior" class will cost, with her equipments and armament, £500,000, and will be cheaper per gun than the existing "Warrior" class (although dearer per gun than the first-rate), containing not only all the very excellent qualities belonging to that vessel, but also those improvements which the careful study of her under construction has enabled those who originally designed her to devise.

Class III.

The New Iron Steam-Corvette.

The new iron corvette will not differ materially from the frigate, except in size and armament. The corvette must have the same speed as the others, and coal for the same distance; but she will carry a much smaller armament; she will have to be 5,000 tons burden, will only carry twenty guns, will cost £300,000 with her equipment and armament; she will do 15 knots.

Comparative view of these three first classes:—

These three first classes have all been designed with a view of being able to act together as a fleet at sea, in all weathers, and under all the circumstances which the widely-dispersed dominions of Her Majesty require. To act together they must all have the same speed; to take to sea on a long voyage, they must all have coal for 5000 miles; and they must all have such proportions of structure, as will make them good sea-boats.

In comparing these classes it will be observed that the largest is much the cheapest. It costs £7500 per gun; the second class costs £10,000 per gun; the third class costs £15,000 per gun.

This comparison of price is very important. It establishes this conclusion: that the speed and length of voyage being given, the larger ship is the better bargain, and the cheaper.

Everything, therefore, seems to be in favour of the larger ship. But there exist uses for which a large ship is unnecessary; and there are others to which a smaller ship alone is applicable. Small draft of water, narrow channels, as well as small enterprises, require smaller and admit of less costly vessels.

Wherever, therefore, a large port is to be defended against a powerful enemy, or a channel cleared of a powerful fleet, o the powerful batteries or fortresses of an enemy are to be ove powered, or the fleet of an enemy to be pursued and destroyed, the large ship will have every advantage, economy even included.

It is an important point in the construction of these three great classes of iron steam-ships of war, that though much larger, more powerful, and faster than the existing classes, they need not draw more water, and thus will be able to enter the same harbours.

Comparative view of the three following smaller classes:—

The three first classes already described are all impregnable; that is to say, would be an overmatch, beyond all comparison for any wooden ship of the same number of guns now in existence. How long a battle with a ship of her own class would last, remains to be seen. The armour of all those ships not only protects the ship herself from rapid destruction, but she has the whole of her guns effectually worked and protected both from shot and shell. The new classes to which we are now descending do not enjoy the same advantages in the same degree. They are only partially protected, and their most vital parts defended.

The reason why this smaller class cannot have their iron armour employed to the same extent and degree is easily seen by considering the circumstances for which they are designed. First, they must have the same speed as the ships of the large fleet, to which they are auxiliaries; therefore they must go fifteen knots; they must be good sea-boats, but they are required to draw much less water, so as to follow a flying enemy where ships of a larger draft cannot follow.

It is physically impossible to give such vessels the speed required to manœuvre with the fleet, and at the same time the draft of water necessary, and a heavy armament enclosed in shot-proof walls. This smaller class can only, therefore, possess impregnability in that smaller degree which the conditions will admit: and in proportion as their draft of water becomes smaller while their speed is maintained, must the impregnability decrease.

The general features, then, of this class are, a high speed equal to that of the first three classes, and partial protection.

Class IV.

The new Iron Steam-Clippers.

I owe the invention of this class to a distinguished foreign Prince, an excellent sailor, who first suggested it to me, and who had already carried it into effect in wood. This class is a clipper of ten guns, four only of which have perfect shot-proof protection, and only to the boilers, machinery, and magazines; the rest of the ship is impregnable to shell under ordinary circumstances, and the six guns which I call unprotected, are only so in the same degree in which they would be so in the existing ten-gun ship. This partial protection, however, suffices to make this vessel an overmatch for any wooden vessel of the same class; as she would be able to sink her enemy at once by means of the shot and shells from which her own vital portions are protected. She has a speed of fifteen knots, and she costs £160,000. She is 2500 tons burden. The intention of this vessel is to act in water where a vessel drawing only sixteen feet can safely manœuvre, such as the Baltic.

Class V.

The new Iron Steam-Sloop.

This ship belongs to the same class as the existing steam-sloops of the navy, except that she is made of iron, and is faster. She has this advantage also over a wooden ship, that her vital parts are made shell-proof, and also, from some points of fire, shot-proof. She is therefore an overmatch for her own class in wood; but, except for distant and end firing, she is no match for the iron classes above her, but she is an overmatch for a much larger ship of the wooden class. She goes fifteen knots, and carries ten of the largest guns, placed so as to fire simultaneously, parallel to the keel, or nearly so. She costs £120,000. Her burden is 2000 tons.

Class VI.

The new Iron Steam-Despatch-Boat.

This vessel is built for speed alone, carries ten guns, and possesses partial protection in a small degree; but she performs sixteen to seventeen knots, in order to enable her to act as a despatch-boat, and keep up the means of communication with the rest of the fleet. Her ten guns can be employed as efficiently as any other existing ship of war. She costs £100,000.

Special Uses of Classes IV. V. and VI.

It is quite plain that Classes IV. V. and VI. would form by themselves an efficient fleet, either for attack or defence. Class IV. would run in, close, and engage the strongest part of the enemy. Class V. would engage at a greater distance, firing in line with the keel, and in that position, thoroughly protected also. While Class VI. would engage in all the lighter duties, which their less impregnability and greater speed would fit them for; but as all of them are incombustible, two of them partially protected, and the last partially shell-proof, they would possess enormous advantages over a wooden fleet. It is to be observed that their greater speed than any existing fleet enables them to choose their own time and place of action, and, as they can all keep together, and all go on sixteen feet draft of water, they form a fleet infinitely an overmatch for any fleet that could meet them on the same draft of water, say in the Baltic Sea.

But where operations were more important and accessible, these three Classes would be auxiliaries only. Class III. would lead them in more important operations, where a still larger Class could not act. Class II. and Class I. would be reserved for such important operations as the following:—(1.) The protection of our arsenals from the attack of a fleet. (2.) The attack of the enemy's fleet, dockyards, and arsenals. (3.) Great naval engagements at sea. For many minor operations, the smaller Classes would be sufficient.

In regard to the principles upon which these six classes are to be constructed, there is a very important distinction to be drawn. The Classes I. and II. are of such dimensions that they are perfectly able to carry, on every portion of them where it is essential they should be shot-proof, armour really impenetrable. By this, I mean such a thickness and strength of iron side as will absolutely stop a shot fired at the vessel with steady aim, in the best direction and at the closest distance. The armour may be made of such a thickness as directly and absolutely to stop the shot.

But in regard to Class III. and lower, there is another principle of which we should avail ourselves. I mean the principle of obliquity. It was proved by Captain Hall in the "Nemesis," that even a half-inch plate of iron would deflect a shot fired obliquely to its surface. It has been proved by many other experiments that thicker plates than those of the "Nemesis" will throw off shot at angles less oblique. And a few months ago it was proved by Captain Hewlett of the "Excellent," that shot fired at plates placed at an angle of about 45 degrees, suffered only one half the injury of plates receiving the fire at right angles. The experiments made by him on Mr. Jones's butt, clearly established the advantage of inclined sides, so far as resisting shot. One plate of iron, 5¼ feet long by 2½ feet wide, took seventeen blows before any part of it was removed, and then the iron was not effectually penetrated. The principle of obliquity of surface to the line of shot then presents us with a mode of dodging the shot instead of meeting it, which will enable us to contribute materially to the strength of all the smaller class of vessels, without loading them with a heavier protection than their size will carry.

OUR IRON GUN-BOAT FLOTILLAS.

A gun-boat flotilla must be formed for quite other uses than any of the previous classes, and should be formed on a principle quite apart. The principles which should govern the construction of gun-boats are three:—multiplicity of attack, subdivision of risk, and shallowness of water.

By multiplicity of attack, they may be able so to distract a large and powerful enemy, as utterly to destroy her before she can destroy them. Suppose, to make this plain, you give me 10 guns in 100 iron gun-boats, and I give you 100 guns in o wooden ship of the line. I think I should effectually prevent you from entering a harbour or smooth water lake which I had to defend. It is true you could run away from me, which is probably all I want you to do; but if you venture to come into my waters, look at our chances. I spread out in two long thin lines to receive you, and I can choose my place, you can choose your time. You attack me. For every shot of mine I have a target to fire at fifty times as great as I offer to you, therefore my chances of hitting you and yours of hitting me are long odds to begin with. Next, I plant a shell in you, which explodes between decks, see what disorganisation I spread through you; you plant a shell in one of my boats, and you sink it, what then? You have sunk a hundredth part of my fleet, and disabled one gun. My shell has blown up your decks, and disabled ten guns. We go at it again. I have exploded twenty shells in you, and you have sunk twenty of my boats (which of course you could not do, because the chances are 50 to 1 against you hitting me), even now how do we stand? My eighty gun-boats unharmed continue their fire. I think no man who understands anything of the effect of modern artillery, will hesitate to say that from this moment the odds are hopeless against you. The odds are 100 to 1 that I have damaged your batteries and your boilers, that your condition is hopeless; but even if you should succeed in destroying twenty more of my gun-boats before I sink you, you will admit that if I return with sixty unharmed gun-boats, having sunk you, I have done a good day's work. So much for multiplicity.

But I have many disadvantages which I am willing to admit. Your larger vessel can beat my little gun-boats in speed. A bigger vessel if equally well made can always outstrip a smaller one in speed. A larger vessel equally well made, can always secure a more steady platform for her guns than a smaller one. Therefore, by multiplicity, little gun-boats possess advantages in smooth and shallow water, which they lose at sea. Still the advantage of multiplicity and size of target is long odds, and the circumstances of weather and water must be much against them to counterbalance it.

The sphere then of gun-boats is shallow and smooth water, both for attack and defence, and its most effectual means are sub-division of risk and multiplicity of attack.

These principles give rise to a class of vessel which has never yet been adopted by our Admiralty, although so obviously good. Small boats can never be fast, can never have stable platforms in rough weather. To utilise them therefore to the utmost, their risks should be as much sub-divided as possible, and they should be used only in the shallowest water. Adopting these two principles, we can construct three classes of vessels of iron.

GUN-BOAT FLOTILLA.

Class I.

To turn to account to the utmost the principle of sub-division of risk, and multiplicity of attack, we must have but one gun of the largest class in one boat of the smallest class. The smallest steam vessel in which a 100-pounder gun can be efficiently carried, is 120 tons burden; and it requires thirty horse-power to drive it; its complement is twenty-five men, and it is partly shot-proof; it has about eight knots speed under steam, and draws between four and six feet of water. The cost of this size with its equipment and armament is £5000.

This class of vessel is designed to be used only in numbers. They are so formed as when fighting to form one continuous floating battery. They form in line, suddenly disperse, and return, just as riflemen would do on land. A hundred of them cost only half a million, while one iron-plated first-rate of the same number of guns costs one half more. I cannot tell whether they would be an over-match under all circumstances for an iron-plated ship of the line of the new class; but they would certainly be an over-match for one built of timber, and indeed I doubt very much whether twenty such gun-boats in decently smooth water could not sink or capture a ship of the line in a quarter of an hour.

The only failing, as I have said before, of little boats, is thei inevitable want of speed, and of a stable gun platform; but the have the counter-advantages of being able to run into wate where their larger enemy cannot follow them, and they are therefore able to command narrow channels, in shoal water, against heavy odds.

We ought at least to build fifty of these every year until we have enough. These little boats have another great advantage in being built of iron. They could be laid in a long row, under an inexpensive shed, on a sloping beach, high and dry, within 20 feet of high water, painted outside and in whenever required; and so kept that within twelve hours from the order being received, the whole flotilla would be afloat and under steam. This could all be done by no other agency than the crews designed to man them, and the coast-guard should be drilled in the exercise of getting them afloat and laying them up again. No such contingency as has destroyed the efficiency of the wooden gun-boats, laid up at Haslar, could take place with these, and so long as they are kept high and dry, so long they would need no repairs.

CLASS II.

A larger class of boats of higher speed than these is indispensable, to act with them, to keep up communication, to succour the distressed, and assist the squadron in advancing or retiring. For this purpose we must have paddle-wheel despatch-boats, which I shall call Class II. They are designed to act, not in numbers, but singly, as auxiliary and supplementary to the flotilla of gun-boats, Class I. With every ten gun-boats there should be at least one despatch-boat. They require to be 300 tons and 100 horse-power; each will mount two guns, both capable of being fired to the front in a line parallel with the keel. They should be able to go either end foremost equally well, and it is indispensable that they should have a considerably higher speed than the flotilla—at least 10 knots—and that they should go on the same draft of water, and be partially shot-proof. Ten of these despatch-boats would cost £150,000.

CLASS III.

Is a larger class of gun-boat flotilla, vessels of about 400 tons, screw vessels, carrying two large guns, both capable of being fired parallel to the keel, and both possessing the quality of good sea-boats, drawing 8 feet of water, partially shot-proof, and capable frem their size of navigating any sea, and from their length and power able to steam 10 knots. The difference, therefore, between Class I. and Class III. consists merely in this, that Class III. is a larger vessel, made so for the purpose of being sent further from home, and on voyages where small draft of water is of less consequence ; in other respects their manœuvres and their co-operation would be similar to Class I. They would cost £20,000 each.

CLASS IV.

This class is supplementary to Class III., and should consist of gun-vessels like the "Recruit" and "Weser" (now in her Majesty's service), only larger and faster, and like them, armed with 4 large guns, firing parallel to the keel; to be also partially protected; to be capable of navigating either end foremost; and to be despatched on detached service, singly and especially. There should be one of them in action attached to every ten of the previous class.

In regard to these two last classes, it may not be necessary for some years to construct more than a very few of them, inasmuch as we already possess large numbers of wooden boats of this size, which, though they will neither have the speed, draft of water, nor protection which the iron vessels have, are, nevertheless, sufficiently powerful to be very useful for many kinds of service. The special object of now pointing out these classes is, that we should be prepared, as the others decay, to supply their places gradually by a new and improved kind of gun-boat. Each vessel of Class IV. would cost £25,000.

TOTAL COST OF THE NEW IRON STEAM FLEET.

I cannot conceive our Channel Fleet to consist of less th ten ships of the line, of the new class. This fleet would carry 1000 guns in shot-proof battery, would be propelled by 25,000 horse-power. The cost of this fleet fully equipped and armed is

£7,500,000.

2. It has been usual to demand twice as many frigates as ships of the line. But as each frigate of the new class would be a match for four of the enemy, I will take only ten of them, and ten of the next smaller class; we shall thus have ten frigates of the new class, costing fully equipped and armed, and carrying 500 guns in shot-proof batteries, propelled by 18,000 horse-power, costing

£5,000,000.

3. The corvette class being a match for at least two of the old frigates, may fairly rank as frigates in the fleet; ten of these carrying 200 guns in shot-proof batteries, propelled by 15,000 horse-power, costing

£3,000,000.

The Channel Fleet will therefore cost

£15,500,000.

The Auxiliary Fleet.

Class IV.—Ten Steam-Clippers, costing

£1,500,000.

Class V.—Ten Steam-Sloops, costing

£1,200,000.

Class VI.—Ten Despatch-Boats, costing

£1,000,000.

Total Auxiliary Fleet,

£3,700,000.

Thus, when we look the difficulty in the face, it disappears. The maintenance of our navy at present costs us £5,000,000 a-year. And the construction and repairs of the fleet in our Dockyards costs us another £5,000,000.

Supposing, therefore, that we were in a position simply to buy a fleet, for so much money, we could buy it at once for an outlay, say of £20,000,000; a sum which we have spent over and over again on the construction, alterations, and repairs of our present wooden navy.

Comparative cost of the annual maintenance and repairs of an Iron Fleet in ordinary.

I will suppose that we have paid down our £20,000,000 for our iron fleet, and got it. It will not be difficult to show that the value obtained for this £20,000,000 will make it the most economical investment the country has ever made in war material. An iron ship never decays if well cared for. At least, I have not lived long enough to know how long an iron ship, built of good material, on right principles, will last. There are vessels twenty years old, showing no symptoms of general decay, even though hard worked in every climate all these years: all the hulls want is paint and care.

The bane of the wooden navy is dry rot. You build a magnificent ship of the line; you launch her in time of peace; you lay her up for five years in the harbour of Portsmouth; and one fine morning, on a threat of war, a telegraphic message is sent that this new ship is to be put in commission. She is brought into dock to be overhauled and put forward, and my lords are informed that her timbers are so much decayed, that she will require a thorough repair at an unknown cost of time and money, and that, therefore, some other ship must be put forward. This is a mild case, for it is just as probable that this report will be followed by another—that the master builder finds that, on further examination, the ship's decay is so extensive, that he must recommend to my lords that the ship be broken up. This latter is, however, a common, but not the most usual case. The ship does get a thorough repair at something like half her original cost, and her "defects having been made good," she is again laid up in ordinary, to be again overhauled when the new emergency arises, with the probability of finding that this tim that part of the ship which had not been renewed last ti requires to be renewed this time, on account of the disease having begun to show itself extensively in those parts which had not formerly been removed; and it is made a recommendation to my lords that the necessary repairs should be once more executed, and the defects once more made good.

This is one of the ways in which the money voted for a wooden fleet is enabled to disappear, without the fleet, for which the money was voted, ever making its appearance in a state fit for service.

In an iron fleet there is no such disease as dry rot, nor anything analogous to it. The durability of an iron fleet laid up in ordinary, is certain. An iron man of war, anchored in the Hamoze for twenty years, receiving a decent coat of paint when required, will be as fit for service any day in twenty years as it is the first day. For this purpose it is only necessary that it should be wholly of iron, or at least, that wood should to the utmost possible be kept out of the construction.

The maintenance, therefore, of an iron war fleet in time of peace, may amount to 1 per cent. on its value per annum.

The annual maintenance, therefore, of our fleet of £20,000,000, would be, when laid up,

£200,000.

Further Economical advantages of the Iron Fleet.

A further great economical advantage would arise from the possession of a large and powerful iron steam fleet, namely, that our steam fleet would be manned by *one fourth of the number of seamen* that would be requisite to man a wooden fleet of equal effective strength. In steam-ships of this class, the number of men required would be governed by what was necessary to work the guns. It will take 10 men to a gun, and one whole steam fleet of 30 of the three first classes, would only comprise 17,500 men, and would certainly be an overmatch for all the navies in the world put together. The total number of men at present employed in our fleet and coast-guard service, is 85,500.

In regard to the classes of vessels IV. V. and VI. I take them at 6000 men for the three, thus making in all about 24,000 men.

Now, as each of these iron-plated ships will sink at least four ships of the same number of guns, at the lowest computation, before they will be able to sink her, it is quite plain that this fleet is a match for a fleet of four times the number of sailors.

It is also worthy of note, that in this case the chances of loss of life will be as 1 to 4.

How the construction of the Iron Fleet may affect the question of manning the navy.

I have been informed by officers of great experience, who have the interests of the service most deeply at heart, that nothing distresses them more than a certain course of policy which has been persistently followed in the Admiralty, until the number of first-rate sailors has been greatly reduced, and the quality and character of the seamen lamentably lowered. Of our 50,000 seamen not 25,000 belong to the superior class we have been accustomed to have.

The construction of the iron fleet presents an opportunity of setting this matter speedily right, and supplies us at once with the means of doing it most effectively. I think I have under estimated the relative value of a gun and a man in the new fleet, over a gun and a man in the old. I have taken the very low standard of one gun and one man being equivalent to four guns and four men, although I might possibly be justified by future experience in placing the odds as high as 10 to 1.

It holds good, therefore, that 25,000 sailors in the new fleet will be as effective as 100,000 in the old. The advantage to be taken of this is as follows.

Let us pick out for the new iron fleet 25,000 of our very best seamen; let them have higher wages, better training, more education, greater comfort, and in short every advantage that good pay, knowledge, and kind treatment can give them. If those 25,000 men are as good as 100,000, we can afford to do what we have said with advantage. I think it is a sound opinion that in our army the improvement of military weapons has raised the rank, education, and general well-being of the soldier; I have no doubt that the same good effect will arise naturally out of our providing a much higher class of weapon for the sailor. The new fleet is this improved weapon.

The same conclusions I think apply to the officers of the navy. The new class of fleet will create the demand for so high a degree of skill, character, and knowledge on the part of the officer who has to wield and apply these new structures; the value of the structures themselves is so great, their loss would be so terrible, and their capacities of performance give so great a scope for the exercise of all the highest qualities of mind; that we can well afford to pay for the highest quality of officer, and indeed we cannot afford to have mediocrity at any price in the management of such a large and important national property as the new First-Rate. Not only must the officers in every department of the ship be more skilled, but in proportion as skill should preponderate over force, so must the number of officers compared to men be greater.

How the new Iron Fleet would affect the scientific department of the Admiralty.

We have already seen how the improved fleet requires a higher order of skill and knowledge in those who man it, and those who wield it, just in proportion to its higher capabilities of performance. The same observation holds true with reference to the scientific department of the Admiralty. In former times it has been reckoned enough for the constructive department of the Admiralty if they possessed science enough to calculate decently the displacement of a ship; and not many years ago it was too commonly found that even this great effort of skill exceeded the powers of the department of Surveyor of the Navy. But the introduction of steam compelled also the introduction into the Surveyor's department of much higher skill and knowledge; and there can be no doubt that the present department stands much higher than in those days. But from this time forward, it is manifest that the demand upon the department of scientific construction (commonly called the department of the Surveyor of the Navy) requires powers and functions vastly greater than have ever heretofore been conferred upon it; and that department, with a false economy, has neither the powers, the functions, nor the pay, which the very serious national interests of which it ought to have the reponsible control, imperatively demand. Every pound wasted in false economy there costs the country thousands. The success or failure of the new iron fleet is the success or failure of the nation.

How the construction of the Iron Fleet may affect the naval estimates of annual expenditure on the fleet.

If my assumed proportion of 4 to 1 be, as I think, an under estimate of the relative efficiency of one man and one gun in the iron fleet, as compared with one man and one gun in the wooden one, we can easily see this must affect the current annual expenditure of the fleet. Of course it would be presumption in me even to suggest the manner and degree to which it would be the policy of this country to maintain or extend our naval power; but if the 25,000 men can be rendered as efficient as 100,000, there must be some very serious cause which is not obvious to me if the current annual cost of our fleet afloat, which is now about £5,000,000, cannot be seriously reduced in amount, at the same time that it is greatly enhanced in efficiency. It appears to me that in time of peace it will be possible to combine greatly reduced annual cost, with perfect preparation for instant war, from the moment when an iron fleet shall be entirely substituted for a wooden one.

How the construction of the Iron Fleet may affect the naval estimates of annual expenditure on the dockyard establishment.

The other £5,000,000 annually are expended mainly in our dockyard establishments. If the new fleet is purchased at once in the private iron building establishments of the country, as appears to be intended, the nation will escape altogether from the great inevitable cost that would follow the erection of new establishments in our dockyards, for the purpose of constructing new fleets of iron. If it be found that the establishments already existing in the country are sufficient to supply the iron vessels as fast as the country finds the money, we shall only for the future have to pay for the fleet itself, and not also for the erection of new establishments for its construction; the present establishments for the building of wooden vessels would therefore be discontinued. How great the saving would be that would be effected in this manner it is not difficult to foretell. The true cost of a fleet would become for the future a known and definite quantity. A ship bought and paid for would be a definite item in the national expenditure. Dry rot, premature decay, "thorough overhaul," "cutting down," "lengthening and conversion," and a host of similar mysterious indefinite but very cumulative items, would disappear, and instead, the Government would buy a ship, pay for it, and have it.

It appears, then, that there are two sums of £5,000,000 each, which comprehend the great items of present expenditure on the navy; and it is extremely difficult for me to see in what possible way it could be contrived to spend that annual sum in manning and maintaining the iron fleet.

THE END.

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